#325

PIONEER 9

BEACON SCINTILLATION OBS.

68-100A-03F

PIONEER 9

BEACON SCINTILLATION OBS ON TAPE

68-100A-03F

THIS DATA SET HAS BEEN RESTORED. THE ORIGINAL TAPE WAS 9-TRACK, 800 BPI WITH 25 FILES OF DATA. THE TAPE WAS CREATED ON AN IBM 360 COMPUTER. THE DR TAPE IS A 3480 CARTRIDGE AND THE DS TAPE IS 9-TRACK, 6250 BPI. THE DR AND DS NUMBERS ALONG WITH THE CORRESPONDING D NUMBER IS AS FOLLOWS:

DR#	DS#	D#	FILES
DR02872	DS02872	D22353	1

REQ. AGENT	RAND NO.	ACQ. AGENT
VLP	RC4794	LLD

PIONEER 9

BEACON SCINTILLATION OBS.

68-100A-03F

This data set catalog contains 1 Pioneer 9, Beacon Scintillation Observatory data tape. The tape is 800 BPI, EBCDIC, 9 track and contains 25 files. The tape was created on an IBM 360 computer.

The D and C number is as follows:

D#	C#
D-22353	C-17208

CENTER FOR RADAR ASTRONOMY
STANFORD UNIVERSITY
DEPARTMENT OF ELECTRICAL ENGINEERING
STANFORD, CALIFORNIA 94305

68-100A-03E
F

September 24, 1975

Mr. Lee Dubach
National Space Science Data Center
Goddard Space Flight Center
Greenbelt, MD 20771

ff 1-7 vol 2
1-10 vol 3

Dear Lee:

I am enclosing a magnetic tape and three rather bulky volumes. These constitute the record of our so-called "Format D experiment" on Pioneer 9 during the solar occultation which occurred in 1970-71.

I am distributing copies of the three volumes to various groups of research scientists who have shown an interest in studies of scintillation. In order to make sure that the tape recorded data is permanently available to interested parties, I am giving you our master tape which includes all these data plus a number of other data which will serve no purpose for you. The tape contains 25 files of which only files 11 through 15 will ever need to be distributed to users. Therefore, I have not even explained the card formats for the first ten and the last ten files. The explanation for the files 11-15 is given on the attached page.

Beginning in mid-October, I will change my place of work to the Stanford Research Institute, although for some time I will remain closely associated with Stanford University and will remain an adjunct professor here, directing graduate students and some research. Nevertheless, please note that in two weeks, my new mailing address is

Thomas A. Croft
SRI - Building 44
Menlo Park, CA 94025

Sincerely,

Thomas A Croft

Thomas A. Croft
Adjunct Professor

TAC:mal
Enclosure

Data referred to in SU-SEL-75-027 report can be found on file 15, tape "MT03 - Format D"

The format of data on this tape:

Record = 80 characters (card image)

44 logical records per block

3520 characters per block

Each group of data is preceded by <u>control</u> card followed by <u>data cards</u>.
49.8 MHz first then 423.3 MHz for each 9D number.

Control card

```
123456789A123456789B123456789C123456789D123456789E123456789F123456789G123456789H
9D  1  49.8 1087  129  0.11911E-14 -119.240  0.43594  -53.202  -44.751
```

```
         9D  1 = Identification no. for a 30-second record of Format D data
          49.8 = Frequency in MHz (either 49.8 or 423.3)
          1087 = Total number of Format D Data points in the record
           129 = Maximum lag of the autocorrelation function
                 to be used in power - spectrum estimation
   0.11911E-14 = Average power, Watts
      -119.240 = Average power, dBM
       0.45394 = Estimate of scintillation index
       -53.202 = Spectrum normalizing factor in dB
       -44.751 = Spectrum scaling factor in dB
```

Data card

```
123456789A123456789B123456789C123456789D123456789E123456789F123456789G123456789H
HAM    1  49165 45618 26833 20426 12792 15979 26058 28910 24764 10269  6892  9206
```

```
     Ham = Card Type Identifier (Mnemonic for "Hamming Window")
       1 = Sequence number of the first data pt. on each card (1,13,25 etc)
   49165 = (Normalized spectrum in dB)x1000 (12 entries per card)
```

Data referred to in SU-SEL-75-026 report can be found on files 11 through 14, tape "MT03 - Format D"

The format of data on this tape:

Record = 80 characters (card image)

44 logical records per block

3520 characters per block

Each group of data is preceded by a <u>control card</u> followed by <u>data cards</u>. 49.8 MHz first then 423.3 MHz for each 9D number.

Control card

```
123456789A123456789B123456789C123456789D123456789E123456789F123456789G123456789H
9D  1 49.8                      0.14812749E 09      0.14794970E 09    349.407    83.011
```

```
          9D  1 = Identification no. for a 30-second record of Format D data
           49.8 = Frequency in MHz (either 49.8 or 423.3)
 0.14812749E 09 = Sun-Pioneer distance in Km
 0.14794970E 09 = Sun-Earth distance in Km
        359.407 = Earth - Sun - Pioneer angle, degrees (posigrade)
         83.011 = Earth - Pioneer - Sun angle, degrees (posigrade)
```

Data card

```
123456789A123456789B123456789C123456789D123456789E123456789F123456789G123456789H
FDB 1   1 444 564 559 551 395 535 531    0 536 542 404 436 563 563 561    0
FDB 2   1 433 426 406 399 395 402  0     0 419 394 410 417 426 436 0      0
```

```
FDB = Card Type Identifier
  1 = Frequency either (1 = 49.8 MHz)
                       (2 = 423.3 MHz)
  1 = Sequence in record (1 - 68)
      From Column 10 onward:
           3 digit number = Arriving signal power at the spacecraft
                            in dBm (-10) -1000
                            (i.e., -156.4 dBm becomes 564)
           0              = Recording was blocked and hence is unknown.
```

SU-SEL-75-027

PROCESSED DATA DERIVED FROM THE PIONEER 9 SCINTILLATION MEASUREMENTS AT 50 AND 423 MHz NEAR SOLAR OCCULTATION

by

H. Chang, T. A. Croft and M. L. Goldman

August 1975

Prepared under

National Science Foundation
DES 75-00493

and

National Aeronautics and Space Administration
NGR 05-020-407

Center for Radar Astronomy
Stanford University
Stanford, California

Chapter I

INTRODUCTION

From 1965 until 1975, Stanford operated the dual-frequency experiment aboard the sun-orbiting spacecraft, Pioneer 6, 7, 8 and 9. The purpose of that experiment was the measurement of the electron content of the solar wind through observation of the difference of transit time delay at 50 and 423 MHz. Signals at these two frequencies were sent from earth to the spacecraft, which was equipped with receivers and the associated data processing circuitry to obtain the difference observation and to encode it digitally.

The spacecraft were spinning at about 1 revolution per second and had a three-lobed antenna pattern. For the purpose of engineering evaluation of the instrument status, the spacecraft incorporated a capability to record the strength of each signal about 36 times per second in 30-second intervals. This recording capability has since been used as a means for the study of scintillation of the radio signals in the solar wind. Here we present plots which form one part of a study of the scintillation of Pioneer 9 signals over a wide range of solar elongations.

The Pioneer spacecraft orbit the sun roughly in the same orbit as that of the earth, but two of them pull steadily ahead of the earth and two of them fall behind. In the case of the last spacecraft, Pioneer 9, it was launched so as to move ahead very rapidly with the result that, in 1970, it reached a point halfway around at which point it was essentially occulted by the sun. As seen from the earth, the spacecraft slowly approached the sun and then, in 1971, emerged from behind the sun and continued its progress around the solar system. By making occasional 30-second recordings of the signal strength as described above, we have obtained a body of recordings of the scintillation in the solar wind which are partially reported here.

This work has led to a unique result; there is no similar data available from any other source, and to our knowledge, there is no planned spacecraft which is capable of yielding this kind of data. We wish to make these results available to others in the scientific community who have an interest in solar wind scintillation. Because of the sheer volume of these data, we have determined that it is desirable to distribute them in the form of three reports. This report is the third in that series of three. Here we present the spectrum plots of the amplitude fluctuations in the radio signal, together with plots of the autocorrelation function and listings of the spectra and scintillation indexes.

The first report provided plots of the amplitude after correction for the effects of the spinning antenna. The second provided listings of these same amplitudes. It was visualized that the numbers could be recovered from that second report by an optical data reader in future years. For a limited time, we will be prepared to provide these data on magnetic tapes. This third document presents both plots and lists of the spectra of these same fluctuations. For many purposes, the spectra are the most informative data forms. The scintillation indexes and autocorrelation functions have also been calculated and are included, except that lists of the autocorrelation functions are not included here.

These three documents will receive limited distribution since they are intended to serve primarily as a data archive to be used as a subject for future research in other institutions. No analysis or discussion is included in any of the three documents; all such discussion is included in a work now being prepared by Chang, which will also include examples of the more interesting plots. The three reports are:

1. Plots of the signal strength vs. time; "Scintillations in amplitude of simultaneous 50 and 423 MHz spacecraft signals at many elongations due to turbulence in the solar wind". SU-SEL-75-025. By T. A. Croft, M. L. Goldman and H. Chang.

2. Listings of the same signal strength records: "Numerical records of the amplitude scintillations measured by Pioneer 9 at 50 and 423 MHz". SU-SEL-75-026. By T. A. Croft, M. L. Goldman and H. Chang.

3. Spectral plots and listings, autocorrelations plots, and scintillation indexes. "Processed data derived from the Pioneer 9 scintillation measurements at 50 and 423 MHz near solar occultation". SU-SEL-75-027. By H. Chang, T. A. Croft and M. L. Goldman.

Chapter II

BACKGROUND OF THE SPECTRUM PLOTS

In the body of this report there are approximately 200 plots, each of which is identically structured and composed of four subplots. Of these four, the top three show the same spectrum with three different abscissa scales. The ordinate represents the log of power in decibels whereas the abscissa is some function of frequency. In the top subplot, the abscissa is the log of frequency, in the next subplot it is linear in frequency, and in the bottom subplot the abscissa is the square of frequency.

The purpose of the three plots was to aid in the visual search for evidence of a power-law spectrum, an exponential spectrum or a Gaussian spectrum. The logic is as follows:

(P = power, F = frequency, k = a constant)

Power Law:	If $P \propto F^k$,	then $\log P \propto \log F$
Exponential:	If $P \propto e^{-kF}$,	then $\log P \propto F$
Gaussian:	If $P \propto e^{-kF^2}$,	then $\log P \propto F^2$

To simplify this qualitative explanation, other constants and some minus signs have been neglected. The essential point is that the spectrum will tend to lie along a straight line in one of the plots if the assumed form associated with that plot is correct.

The ordinate axis spans a range in decibels which is given by the caption in the upper left corner. This range was selected by the computer so that its peak is at the level of the strongest point and its baseline is at the level of the weakest point. The reader must beware that this variation in total scale does not distort his judgement of the resulting spectral shapes. Along the ordinate axis is a tick mark placed by the computer at either 1 or 10 dB; the 10 dB tick was placed on all plots where the range exceeded 10. Otherwise the 1 dB tick was used. In all cases the baseline is located at 0 dB, the level of the weakest point.

The scintillation index is given numerically above the label which reads "autocorrelation function". Associated with this is another label which tells the total number of autocorrelation points and shows how many of them were used as a basis for calculating the spectrum above. This selection was either 33, 65 or 129; the choice controls the lowest frequency represented by the spectrum, as is evident in the axis labels for the "log F" plot.

The bottom subplot on each page shows the autocorrelation function calculated directly from the data which were given in the earlier reports in this series. The first few records (particularly 1 through 5) are non-representative because they are dominated by residual effects of the spinning antenna pattern, as was discussed in the first report. The baseline is drawn at the zero level in all cases when the minimum value of the ordinate is negative. If the minimum value of the ordinate is positive, then the baseline is drawn at that level. This approach requires that the reader be careful in observing the axis labels, but it offers the virtue that the plots are drawn as large as is practical in the available space.

Chapter III

SPECTRA OF THE BEST SCINTILLATION RECORDS

During the first 9 records, the radio path was comparatively distant from the sun (at least 0.7 AU) and so the stronger scintillation records begin with record 10. Beginning at about record 84, the path again began to recede from the sun until, by record 98, it was back beyond 0.7 AU. As a result, the prime scintillation records are numbers 10 through 85 or so, but the records just before and after this sequence are of interest because they provide comparative data at greater elongations. Therefore in the prime data set we have included all records originally numbered from 1 through 98, of which 77 are presented here.

Each spectrum is a reflection of the conditions on the day of the record, and it is also influenced by the number of points from the autocorrelation which were chosen for spectral analysis. This choice was somewhat subjective, and we present in this section only those records obtained when we made what appears to have been the optimum choice. In the next chapter we will present the spectra which were derived from the records made for the purpose of amplitude calibration; these are the same as the records whose amplitude histories were given in Chapter IV of the first report. In the next following chapter we will present some spectra calculated for records 1 through 98 in which we have used alternative choices of the number of points. This will illustrate by example the manner in which the spectra are affected by this choice.

Chapter IV

SPECTRA OBTAINED FROM THE AMPLITUDE CALIBRATION RECORDS

Records 99 through 112 were obtained when the Pioneer 9 passed near the earth after having gained one lap in its race with the earth around the sun. As was explained in the first report, we operated for about 15 seconds at one power level and then we changed the power level for the last 15 seconds of each record. In the case of records 100 through 105 the bit rate was 256, whereas in all other records it was 512. This lower bit rate caused the record to last 59.5 seconds, but it also eliminated the sun pulse with a consequent deterioration in our ability to compensate for the spinning antenna pattern. After record 105, we returned to the higher bit rate and did the best we could to achieve two levels of power in the brief 30-second record. Even so, in record 108 we switched to low power too early, as is evident from the decrease in power level after only 2 or 3 seconds. As a result, for record 108 there is only 1 spectrum given here. For the other records in this group, a spectrum is given for the high power portion of each record and a separate spectrum is given for the low power portion. To recapitulate, for each record there are four spectra:

high frequency, high power
low frequency, high power
high frequency, low power
low frequency, low power

The transition between power levels took several seconds and we have eliminated the transitional observations since the changing power would affect the statistics of the fading. As a result, these data strings are shorter than 15 seconds, on the average.

Chapter V

ALTERNATIVE VERSIONS OF THE PRIMARY DATA

Instead of calculating tho spectrum directly from the data, it is advantageous to calculate the autocorrelation function first and then to use part of the autocorrelation function as a data base for the calculation of the spectra. The use of too many terms leads to a spectrum so noisy that the intelligence is masked. The use of too few terms leads to spectral shapes having no statistical significance. The choice is necessarily subjective although, with a little trial and error, it is usually obvious where the right choice may lie within a factor of two. During the trials which were made to determine the optimum selection for this project, some spectra were generated which were not used in the analytic work that followed. They are presented in the following pages since they may be of interest to some readers who wish to consider alternate avenues to the calculation of spectra.

Chapter VI

LISTINGS OF THE SPECTRAL DATA

The reader who is familiar with the second report in this series, which also contain listings, will find that these listings are almost self-explanatory. We have chosen to include them in the same report with their associated plots because so few extra pages are involved that they do not warrant a separate report. Also, unlike the FDB data cards, it is envisioned that some readers might like to see these listings in order to perceive the structure of the spectra to a finer scale than can be conveniently derived from the plots.

As before, there is one header card which precedes each body of data cards. For each record, there is a header plus a body of data cards for each frequency.

In the header card, there are 10 items listed. The first one is the "9D" code signifying Pioneer 9 and its Format D. The second item is the record number and third is the radio frequency of the observation. The fourth item gives the total number of points in the autocorrelation function and the fifth gives the number which was chosen for spectral analysis. The sixth and seventh items give the average power, first in watts and next in dBm. Next is given an estimate of the scintillation index. The last two items are the spectrum normalizing factor in decibels and the spectrum scaling factor in decibels.

The cards which contain the data begin with the 3 letter designator "HAM" which is a mnemonic for Hamming, whose window was used in the data processing. The first number is the card number, useful as a means for detec' ıg and correcting a shufflo. F lowing this, each data card contains a dozen numbers which give the spectral points in thousandths of a dB. Thus, 49165 means 49.165 dB. The base of this scale is the same as that of the plot; that is, zero dB represents the lowest point in the spectrum. Trailing zeroes in the last card indicate data missing from the matrix because the number of points used for computation was not a multiple of twelve.

In this section, we present only the listing for the first 98 records. The listings for the autocorrelation and the listings for the scintillation records of Chapters IV and V are not presented here but, for a limited time, we will maintain a capability for reproducing these data on magnetic tapes for use by other investigators who may wish to perform independent analyses.

For the purpose of reproducing the enclosed listings full-size, we have shortened the HAM cards by removing the designator "HAM" and also the card number. This was done in a manner which precluded shuffling, and so the deleted material would have served no purpose in this listing. Those who use these data on our magnetic tapes should be wary, since the tapes still contain the designator and the codes at the beginning of each data card.

Report #2

SU-SEL-75-026

NUMERICAL RECORDS OF THE AMPLITUDE SCINTILLATIONS MEASURED BY PIONEER 9 AT 50 AND 423 MHz

by

T. A. Croft, M. L. Goldman and H. Chang

August 1975

Prepared under

National Science Foundation
DES 75-00493

and

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NGR 05-020-407

Center for Radar Astronomy
Stanford University
Stanford, California

Chapter I

INTRODUCTION

For almost a decade, Stanford University has operated the dual-frequency experiment aboard Pioneers 6, 7, 8 and 9. That experiment was designed to measure the electron content of the solar wind through observation of the difference of transit time delays at 50 and 423 MHz. Signals at these two frequencies were sent from Stanford's 150-foot dish to the spacecraft, which was equipped with receivers and associated data processing circuitry needed to obtain the difference observation and to encode it digitally.

The spacecraft were spinning at about 1 revolution per second and had a non-uniform antenna pattern. For engineering purposes, the spacecraft receivers incorporated a capability to record the strength of each signal about 36 times per second in 30-second intervals. This recording capability has since been used as a basis for the study of scintillation of the radio signals in the solar wind. Here we present listings which form one part of that study of the scintillation of Pioneer 9 signals over a wide range of solar elongations.

The Pioneer spacecraft remain near the ecliptic plane, but two of them pull steadily ahead of the earth and two of them fall behind. In the case of the last spacecraft, Pioneer 9, it was launched so as to move ahead very rapidly with the result that, in 1970, it had gained half a rotation, at which point it was occulted by the sun. As seen from the earth, the spacecraft slowly approached a position behind the sun and then, in 1971, it emerged from behind the sun and continued its progress around the solar system. By making occasional 30-second recordings of the signal strength as described above, we have obtained a body of recordings of the scintillation in the solar wind which are reported here.

There is no similar body of observations available from any other source. To our knowledge, there is no planned spacecraft which is capable of performing this kind of measurement. The results of this experiment are being processed by a doctoral candidate (H. Chang) and his work is nearing completion. At this time, we wish to make these results available to others in the scientific community who may have an interest in solar wind scintillation. The data volume is too large to be included in Chang's dissertation and so we have determined that it is desirable to present the data in the form of three reports. This report is the second in that series of three. In the first, we presented plots of the amplitude fluctuations in the radio signal after correction for the spinning spacecraft antenna. In this second document, we provide a list of the digital representation of these same data, from which the numbers could be recovered in a form suitable for computer processing by means of an optical data reader. For a limited time, we will be prepared to provide these same data on magnetic tapes. It is the author's judgement that optical character readers will become common accessories in the computer centers of the future, as they are in present-day newspapers. Then, this report will serve in place of a tape.

The third document will present both plots and numerical lists of the spectra of these fluctuations. For many purposes, the spectra are the most informative data form. The autocorrelation functions and the scintillation indexes have also been documonted and are included in that third document.

These three documents will receive limited distribution since they are intended to serve primarily as an archive to be used as a subject for future research in other institutions. No analysis or discussion of these data is included in any of the three documents; all such discussion is included in the work of Chang, which will also include examples of the more interesting plots and detailed explanations of how they were generated. His work will receive wide distribution and will alert readers to the availability of the three archival reports. These three reports are:

1. Plots of the signal strength vs. time; "Scintillations in amplitude of simultaneous 50 and 423 MHz spacecraft signals at many elongations due to turbulence in the solar wind". SU-SEL-75-025. By T. A. Croft, M. L. Goldman and H. Chang.

2. Listings of the same signal strength records; "Numerical records of the amplitude scintillations measured by Pioneer 9 at 50 and 423 MHz". SU-SEL-75-026. By T. A. Croft, M. L. Goldman and H. Chang.

3. Spectral plots and listings, autocorrelations plots, and scintillation indexes. "Processed data derived from the Pioneer 9 scintillation measurements at 50 and 423 MHz near solar occultation". SU-SEL-75-027. By H. Chang, T. A. Croft and M. L. Goldman.

Chapter II

ESSENTIAL BACKGROUND INFORMATION

Before presenting the listed data and the descriptions of the formats used for the listing, it is necessary to provide some background information about the dual-frequency system and its manner of commutation into the telemetry system. This will make the listing easier to understand.

Each measurement period lasted for 29.75 seconds when the spacecraft was running at its highest sampling rate, 512 bits per second. This highest rate was used for the first 99 records. For records 100 through 105, a bit rate of 256 was used with the result that the records lasted twice as long. However, the listings of those data are not presented here because they were used only as a means for amplitude calibration. At the highest bit rate, successive samples at one frequency occur each 27.34375 msec. The amplitude of each signal was alternately sampled, so the 50 MHz samples were taken midway between the 423 MHz samples, and vice versa.

The measurements were taken in groups of eight, and engineering words were inserted in place of some of the original measurements by the spacecraft commutator. For the 50 MHz data, one in every eight words was thus supplanted; for the 423 MHz, two out of every eight were supplanted. This was the source of most of the data loss in the system, but the problem was not serious because of the uniform distribution of the loss coupled with the fact that the scintillations under study are slow in comparison to the sampling rate.

There is another source of data loss due to the presence of "sun pulses" which were inserted once each spacecraft rotation when a light sensor pointed toward the sun. During the sun pulse, digital codes were placed in the telemetry string in place of dual-frequency data. Sometimes this meant the loss of one data point and sometimes two, depending on timing. Since the spacecraft rotation rate and the bit rate were not coherently related, it will be seen that the sun pulse falls in different places on different records and there is no pattern to its placement. The sun pulses repetition rate is nearly constant at 0.995 sun pulses per second. In fact, the small variations in sun pulse placement were used by us as a basis for determining how fast the spacecraft was rotating. This background information should be of no practical value to the reader except insofar as it explains the reason for the occasional losses of data. We have already removed the effect of the rotating antenna pattern and so the spin rate is no longer important unless at some future time an effort is made to improve upon our correction for the variations in gain.

Due to the combination of sun pulses and the insertion of engineering data, 15% of the 50 MHz samples have been lost and 28% of the 423 MHz samples were lost. This loss occurred at the commutator in the spacecraft and there was never any opportunity to regain access to the missing data. The loss has not proved troublesome since the sampling rate was higher than necessary.

Chapter III

CODING OF THE DATA LISTS

The lists included in this report are numerical representations of the same data which are plotted in Chapter III of the first report in the series. Of the first 98 records, 79 yielded data of sufficient quality to warrant inclusion in the study and they were presented in that first report. Here, we present the 79 corresponding listings. It was decided to present these lists in a separate document because the manner of their use would be quite different from that of the plots. Also, the inclusion of both plots and lists in a single document would lead to a bulky, awkward volume.

These lists are produced from decks of punched cards and therefore each line is no more than 80 characters long. We have found it convenient to truncate the list to 70 columns because the information in the last 10 columns was redundant. This truncation simplified our process for reproducing the lists and also enabled us to present the lists at the same size as the original computer listing. In the future this standard size may make it easier to use a standard character reader on these lists.

Each record is represented by a 49.8 MHz listing and a 423 MHz listing. These single-frequency listings can be as many as 68 cards long, and each is preceded by a "header card" containing useful identification labels and some information about the location of the spacecraft which is essential to an understanding of the level of scintillation encountered. The data cards are called "FDB" cards;

we follow a practice of beginning each card with a 3-letter designator so that we may later determine with those what kind of card it is.

To facilitate an explanation of the card formats, figures 1 and 2 have been prepared. The header card is fully explained by the labels on this figure. However, some additional comments are needed in order to convey a full understanding of the meanings on the FDB cards.

The card code, the frequency number and the card number are sufficient to identify the location of a card within a record in case there is an accidental scramble of the cards. The frequency number is 1 for 49.8 MHz and 2 for 423 MHz. The card number simply counts from 1, up to as much as 68, identifying the card sequence. All the rest of the numbers on the card are 3-digit codes identifying a particular decibel level. For example, 535 signifies a level of -153.5 dB, while 434 signifies - 143.4 dB. In other words, one must add 1000, divide by 10 and change sign.

Within the body of data there occur the numbers 1, 0, and -4 through -9. These are codes which replace the lost data and it is possible to tell from the code what the original source of loss was. Code "0" signifies the place where engineering data was substituted. Code "1" signifies the location of a sun pulse symbol. We found by trial that the earliest data were contaminated by faulty numbers representing a transition from data to the sun pulse code in the raw digital recordings. Therefore we had to devise a detection algorithm sensitive to this transient state. All the transient data have been identified and replaced by the negative numbers -4 through -9. Since the original sun pulse codes are replaced by "1", the transient numbers will be found to lie adjacent to a "1" in these listings.

Header Card

Pioneer no. / Format D / Record no. / Frequency, MHz / Distance from Sun to Pioneer, km. / Distance from Sun to Earth, km. / Earth-Sun-Pioneer angle, degrees

```
9C 63 45.8                     0.14079320E 09     0.15188619E 09   196.382
FCB 1  1 349 438 565 419 376 314 362   0 535 409 412 539 546 432 414
FCB 1  2 563 316 406 546 541 417 540   0 552 560  -6   1 419 358 369
FCB 1  3 394 537 537 541 379 408 440   0 565 562 555 547 539 534 533
```

Card code / Freq. no. / Card no.

8th sample always zero

16th sample truncated (always zero)

15 samples per card

Data Cards (as many as 68 per header)

FIGURE 1. FORMAT AT THE LOWER FREQUENCY

```
9C 63423.0                     0.14079320E 09     0.15188619E 09   196.382
FCB 2  1 443 460 437 436 490 632   0   0 413 410 428 425 450 456   0
FCB 2  2 621 626 623 626 620 475   C   0 450 436   1 615 616 507   0
FCB 2  3 451 426 426 433 437 437   C   0 590 409 471 475 612 618   0
```

Freq. no. is "2"

7th & 8th samples always zero

15th sample always zero

FIGURE 2. DIFFERENCES IN FORMAT AT 423 MHz

In practice it is very easy to use those numbers. One writes a digital code which ignores any number which is small. (For example, any number less than 100 is not data.) From the larger numbers, subtract 1000, divide by 10 and change sign. The resulting string will be found to correspond to the plots in Chapter III of the first report.

The listings constitute the remaining body of this report.

```
90  1 45.8                      0.14812749E 09       0.14794970E 09    359.40
FCB 1  1 193 188 181 173 171 167 168   0 177 184 190 193 192 191 183
FCB 1  2 167 162 162 161 171 179 187   0 190 180 186  -6  -8 166 169
FCB 1  3 176 184 194 194 194 192 186   0 174 169 167 169 175 183 187
FCB 1  4 196 191 185 180 171 165 161   0 167 170 179 186 185 189 186
FCB 1  5   1 168 166 170 172 182 190   0 194 194 190 184 179 172 171
FCB 1  6 171 176 182 189 196 192 189   0 177 165 163 162 167 169 177
FCB 1  7 187 193 189 184  -6   1 167   0 172 177 182 189 193 194 193
FCB 1  8 181 173 170 167 168 173 180   0 190 196 195 190 179 174 167
FCB 1  9 162 165 171 179 184 192 190   0 182  -6  -8 166 170 173 180
FCB 1 10 191 194 194 191 186 178 174   0 187 169 175 193 190 195 193
FCB 1 11 184 176 171 165 157 159 163   0 179 186 189 189 186 180   1
FCB 1 12 165 170 175 183 167 192 194   0 190 185 179 172 164 167 168
FCB 1 13 186 192 196 194 185 182 177   0 183 162 164 166 173 185 191
FCB 1 14 189 184 181   1 170 169 172   0 185 189 193 194 193 188 181
FCB 1 15 170 167 180 173 177 185 191   0 192 187 179 170 166 162 162
FCB 1 16 172 176 184 189 190 187 182   0  -6 169 166 174 177 184 191
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78 RECORDS IN FILE 1 OF TAPE

RECORD 1 OF FILE 25
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